

A survey of the reptiles and amphibians of Bondi State Forest and surrounding areas, near Bombala, New South Wales

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ABSTRACT

Reptiles and amphibians in and around Bondi State Forest were surveyed between 1980 and 1984. Nineteen species of reptiles and 15 species of frogs were recorded from Bondi State Forest. Five additional reptiles and two additional frogs were recorded from surrounding areas. Bondi State Forest has elements of both warm and cool temperate fauna. The conservation of reptile and frog communities in this area does not depend upon reservation of large areas of forest habitat. Rather, small reserves may be adequate to conserve populations of most species. Existing riparian strips and retained coupes are probably adequate to conserve viable populations of most species of reptiles and frogs in the area.

INTRODUCTION

The Eden Forestry Region in New South Wales is bordered by Kosciusko National Park and the Australian Capital Territory in the west and north-west respectively and extends from Cobargo near the coast to the Victorian border. It covers a wide elevational range and encompasses diverse habitats from coastal heath to alpine forest.

Until recently the reptile and amphibian faunas of the region were poorly known. Recent surveys (Lunney and Barker 1986; Webb 1981) indicated the presence of rich and varied faunas which lack few of the recognized reptile and amphibian families present in New South Wales. As part of one survey (Webb 1981), intensive sampling was carried out in Bondi State Forest, in the tablelands south of Bombala, between December 1980 and January 1984 to determine habitat preferences across a wide elevational range of about 800 m. Distribution and broad habitat data for reptiles and amphibians in Bondi State Forest and surrounding areas are reported here.

STUDY AREAS

Bondi State Forest is located 30 km south of Bombala, New South Wales, adjoins the Victorian border and extends from Mt Tennyson (elevation 1 055 m) in the west to Nungatta Creek (350 m) in the east (Fig. 1). The western (tablelands) section of the forest adjoins the New South Wales-Victorian border and is flanked by grazing land on its western and northern sides. The eastern section is continuous with forested land to the north (Nalbaugh National Park) and south (Nungatta National Park) and with State Forest extending to the coast. The two sections are almost completely divided by grazing land along the line of the Genoa River. The

tablelands section is defined generally as that area above 800 m elevation and the coastal slope or eastern section below 500 m. There is a narrow intermediate zone (elevation 500-800 m) along the eastern escarpment of the Great Dividing Range.

The climate of the area is characterized by an average annual rainfall of 1 050 mm with a mean summer (January) minimum and maximum temperature of 7° and 23°C and a mean winter (July) range of -4° to 10°C at Bondi State Forest Camp (Hall *et al.* 1981). These data cover tableland weather conditions only. No weather records are available for the coastal slope area east of the Genoa River, though temperatures would be higher and rainfall lower.

Two main geological types occur within the forest. At elevations above 500 m, west of the Genoa River, Ordovician sediments predominate (Beams and Hough 1984). To the east, below 500 m, Silurian-Devonian granites predominate.

The forest in the tableland section is mainly tall open forest of several types, open forest and woodland with some areas of poorly drained bog (Table 1). Much of the tableland forest in and adjacent to Bondi State Forest has been cleared for grazing or pine plantation. Grazing occurs in the bogs of the poorly drained creek catchments. So, grazing land and bog are classified as a single habitat. East of Genoa River, tall open forest occurs along the drainage lines with dry open forest on the ridges. Grazing land along the Genoa River is considered as a separate habitat because of its lower elevation.

METHODS

Several methods were used: pitfall trapping; line transects; time and quadrat sampling; and opportunistic hand-collecting. All have been described elsewhere

Table 1. Vegetation types in Bondi State Forest (after Recher *et al.* 1980).

Vegetation Type	Dominant Tree Species	Understorey
1. Tall Open (Montane) Forest — sheltered sites	<i>E. fastigata</i> , <i>E. viminalis</i>	Mesomorphic — <i>Acacia</i> , <i>Bedfordia</i> , <i>Pomaderris</i> , <i>Lomatia</i> , <i>Polyscias</i> , <i>Olearia</i> , <i>Clematis</i>
2. Tall Open (Montane) Forest — intermediate sites	<i>E. obliqua</i> , <i>E. cypellocarpa</i> , <i>E. radiata</i>	Mesomorphic/Xeromorphic — <i>Acacia</i> , <i>Bursaria</i> , <i>Davesia</i> , <i>Polyscias</i> , <i>Hakea</i> , <i>Lomatia</i>
3. Open (Montane) Forest — exposed sites	<i>E. sieberi</i> , <i>E. obliqua</i> , <i>E. radiata</i>	Xeromorphic — <i>Acacia</i> , <i>Bursaria</i> , <i>Coprosma</i> , <i>Platysace</i> , <i>Hakea</i> , <i>Stylidium</i> , <i>Dianella</i> , <i>Epacridaceae</i> , <i>Fabaceae</i> , <i>Lomandra</i>
4. Woodland (Montane)	<i>E. pauciflora</i> , <i>E. dalrympleana</i> , <i>E. stellulata</i>	Xeromorphic — same as 3
5. Grazing Land (Cleared Woodland) and Bog	—	Grasses and Herbs — <i>Poa</i> , <i>Acaena</i> , <i>Oreomyrrhis</i> , <i>Helichrysum</i> , <i>Lomandra</i>
6. Pine Plantation (various ages)	<i>Pinus radiata</i>	Eucalyptus saplings, <i>Acacia</i> , grasses, herbs and ferns depending on compartment age
7. Tall Open (Coastal slope) Forest-sheltered and intermediate sites	<i>E. obliqua</i> , <i>E. cypellocarpa</i>	Mesomorphic/Xeromorphic — <i>Leptospermum</i> , <i>Casuarina</i> , <i>Kunzea</i> , <i>Lomandra</i> , <i>Acacia</i> , <i>Lomatia</i> , <i>Pteridium</i> , <i>Callistemon</i> , <i>Dicksonia</i> , <i>Bedfordia</i>
8. Open (Coastal Slope) Forest — exposed sites	<i>E. sieberi</i> , <i>E. globoidea</i> , <i>E. agglomerata</i>	Xeromorphic — <i>Casuarina</i> , <i>Acacia</i> , <i>Hakea</i> , <i>Bursaria</i>
9. Grazing land	—	Grasses and herbs

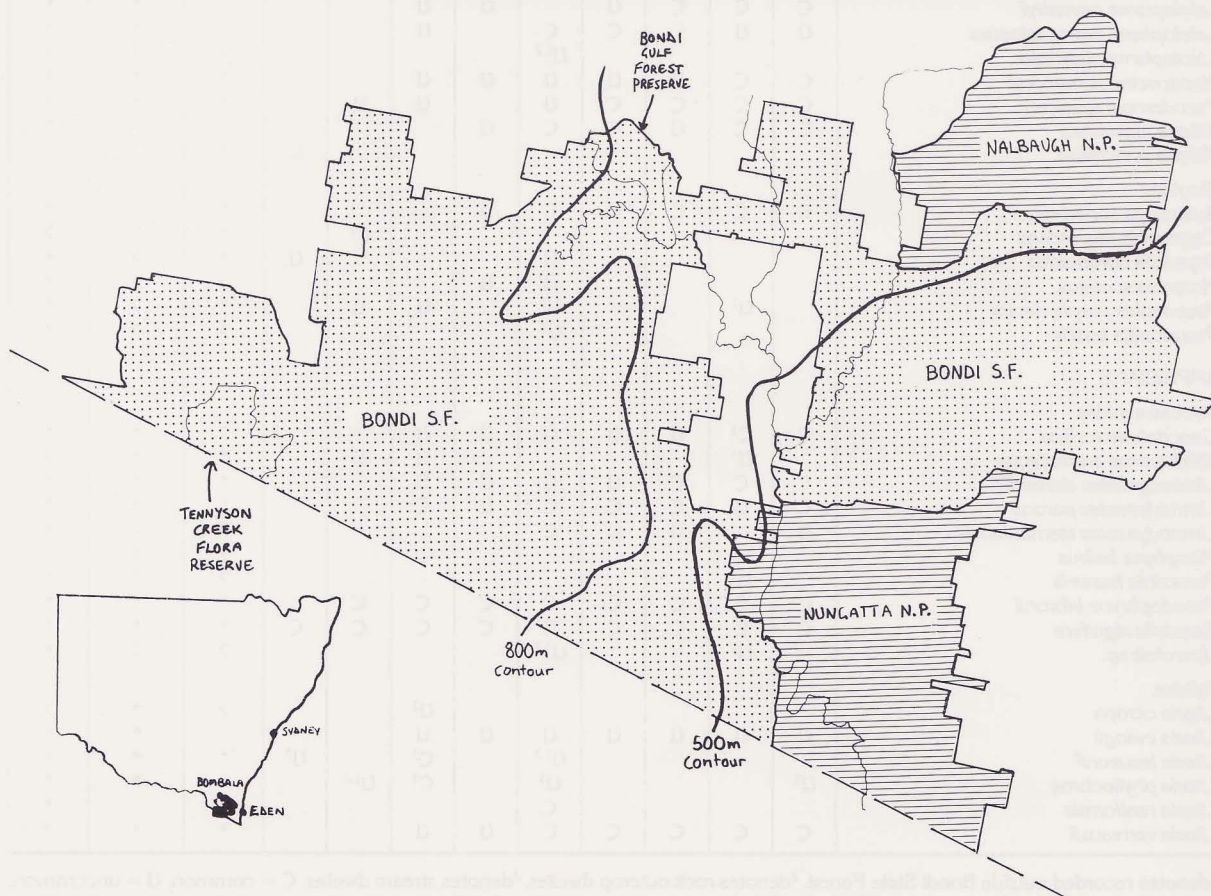


Figure 1. Location of Bondi State Forest and forest reserves in relation to adjoining national parks in the study area.

Table 2. Reptiles and amphibians recorded from Bondi State Forest and adjacent areas.

	Vegetation Types									Elevation (metres)		
	Montane						Coastal Slope					
	1	2	3	4	5	6	7	8	9	−500	500–800	800+
REPTILES												
Agamidae												
<i>Amphibolurus muricatus</i>								C		*	?	?
<i>Physignathus lesueurii</i>							C ³	C ³		*	*	?
Varanidae												
<i>Varanus varius</i>							C	C		*	?	?
Scincidae												
<i>Ctenotus uber</i>					U ¹							*
<i>Egernia cunninghami</i>					U ^{1,2}					?	?	*
<i>Egernia saxatilis</i>		U					C	C		*	?	*
<i>Egernia whitii</i>					C ²				C	?	*	*
<i>Eulamprus heatwolei</i>	C	C	C	C		U	C	C		*	*	*
<i>Hemiergis decresiensis</i>					U ^{1,2}						?	*
<i>Lampropholis delicata</i>	U			C	C		C	C	C	*	?	*
<i>Lampropholis guichenoti</i>	U	C	C	C	U		C	C	C	*	*	*
<i>Lampropholis mustelina</i>	U	C	C	C			U		C	*	*	*
<i>Leiopisma coventryi</i>	C	C	C	U		U	U				*	*
<i>Leiopisma entrecasteauxii</i>	U	U	C	C	C		U				*	*
<i>Leiopisma platynota</i>					U ^{1,2}					?	?	*
<i>Nannoscincus maccoyi</i>	C	C	U	U	U	U	U			*	*	*
<i>Pseudemoia spenceri</i>	C	C	C	C	U		U	U		*	*	*
<i>Tiliqua nigrolutea</i>	C	C	U	C	C	U					?	*
<i>Tiliqua scincoides</i>									C	*	?	
Elapidae												
<i>Austrelaps superbus</i>	C	C	C	C	C	U	U ¹			*	*	*
<i>Cryptophis nigrescens</i>								U ¹		*	?	?
<i>Drysdalia coronoides</i>					U				U	*	?	*
<i>Notechis scutatus</i>					U	U				?	?	*
<i>Pseudechis porphyriacus</i>		U ¹			U ¹		U	U		*	?	*
<i>Pseudonaja textilis</i>					U ¹					?	?	*
AMPHIBIANS												
Myobatrachidae												
<i>Geocrinia victoriana</i>	C	C ¹	U	U	U	U	U			?	*	*
<i>Heleioporus australiacus</i>		U ¹					U	U		*	*	?
<i>Limnodynastes dumerilii</i>	C	C	C	U	C	U	U			*	*	*
<i>Limnodynastes peronii</i>	C	U	C	C	C	U	C			*	*	*
<i>Limnodynastes tasmaniensis</i>	U		U	U	C					?	?	*
<i>Mixophyes balbus</i>							C ³			?	*	
<i>Paracrinia haswelli</i>		U ¹								?	?	*
<i>Pseudophryne bibronii</i>	C	C	C	C	C	C	C	C		*	*	*
<i>Ranidella signifera</i>	C	C	C	C	C	C	C	C	C	*	*	*
<i>Uperoleia</i> sp.		U ¹			U ^{1,2}					?	?	*
Hylidae												
<i>Litoria citropa</i>							U ³			?	*	?
<i>Litoria ewingii</i>	U	U	U	U	U	U	U				*	*
<i>Litoria lesueurii</i> [†]					U ^{1,3}		C ³		U ³	*	*	*
<i>Litoria phyllochroa</i>	U ³				U ³		C ³	U ^{1,3}		*	*	*
<i>Litoria raniformis</i>					C							*
<i>Litoria verreauxii</i>	C	C	C	C	C	U	U			*	*	*

¹denotes recorded outside Bondi State Forest. ²denotes rock outcrop dweller. ³denotes stream dweller. C = common. U = uncommon. [†] = includes specimens which key to *Litoria booroolongensis* but are superficially more like *L. lesueurii*. * = present. ? = likely occurrence based on Cogger (1986), Jenkins and Bartell (1980), Rawlinson (1969) and Webb (1981).

(Webb 1980). Several ecological studies were involved in the overall survey. So, the same methods were not used at all sites and sampling time was not evenly distributed. However, sampling effort was sufficient to be confident that the area was thoroughly surveyed for herpetofauna and that most species in the area were detected.

Taxonomy used in this paper follows Cogger (1986) except for the distinction between the two forms of *Leiopisma entrecasteauxii* (see Pengilley 1972). Voucher specimens of all species recorded during this survey have been lodged in the Australian Museum collection and all locality data has been accessed into the New South Wales National Parks and Wildlife Service WILDATA database.

RESULTS AND DISCUSSION

Nineteen species of reptiles and 15 species of frogs were recorded from Bondi State Forest. In addition, five reptile and two frog species were recorded from nearby habitats (Table 2). The reptile families Agamidae, Varanidae, Scincidae and Elapidae and two frog families, Hylidae and Myobatrachidae were represented in the survey (Table 2). Of the remaining five terrestrial reptile families present in southeastern Australia, only the Gekkonidae and Colubridae are unlikely to be present in the area (Cogger 1986). Clearly, the herpetofauna, particularly the Scincidae, of the area is rich and compares favourably with studies in similar habitats in southeastern Australia (Hutchinson 1979; Lunney and Barker 1986; Smales 1981; Webb 1985).

Habitat Relations

Most species occurred across a wide range of habitats. Some are common in modified habitats such as grazing land and pine plantation. Six species of reptile and seven species of frog were recorded from pine plantations of various age classes (Type 6 vegetation) (Table 1). Some, such as *Nannoscincus maccoyi* and *Leiopisma coventryi*, were recorded from older closed canopy *Pinus radiata* age classes. Of the many species recorded from montane grassland/bog (Type 5 vegetation), only *Leiopisma entrecasteauxii* (Form A) (*sensu* Pengilley 1972) is likely to be restricted to this habitat or adjacent woodland.

The scincid lizards of the tablelands section of Bondi State Forest and surrounding farm woodlots can be divided into broad guilds based on their occurrence in forest, woodland or grassland/bog. *N. maccoyi* and *L. coventryi* were most abundant in more moist, shaded, open and tall open forest (Type 1–3 vegetation) while *Lampropholis guichenoti*, *Lampropholis mustelina* and *Leiopisma entrecasteauxii* (Form B — *sensu* Pengilley

1972) were most abundant in open woodland (Type 4 vegetation). *Lampropholis delicata* and *L. entrecasteauxii* (Form A — *sensu* Pengilley 1972) were most often encountered in grassland/bog (Type 5 vegetation) adjacent to one of the woodlots. *Pseudemoia spenceri* and *Eulamprus heatwolei* were widespread and appear to respond more to habitat features such as logs (Webb 1985) than to floristics or vegetation structure. Other species in the tablelands section (i.e. >800 m elevation), such as *Ctenotus uber*, *Egernia cunninghamii*, *Hemiergis decresiensis* and *Leiopisma platynota*, were only found in rock outcrops in grazing land. Those species occurring predominantly in the coastal slope habitats included *Amphibolurus muricatus*, *Varanus varius* and *Tiliqua scincoides*. All three are relatively widespread in both natural and modified habitats.

Of the elapid snakes, *Austrelaps superbus*, *Notechis scutatus* and *Pseudechis porphyriacus* were found in a wide variety of habitats while *Drysdalia coronoides* was only found in grassland and bog. As Jenkins and Bartell (1980) record *D. coronoides* from open and tall open forest, this species is unlikely to be restricted to grassland/bog habitats. Similarly, *Pseudonaja textilis*, although represented by a single specimen from grassland just north of Bondi State Forest, occurs in other montane and coastal slope habitats (Jenkins and Bartell 1980) as does *Cryptophis nigrescens*.

Most frogs occurred in a wide variety of habitats, their distribution being governed more by availability of water for breeding than by vegetation type. In the montane zone, all the myobatrachid frogs and the hylids, *Litoria ewingii* and *Litoria verreauxii*, appear to disperse widely through the forest and woodland often many hundreds of metres from permanent water. *Litoria raniformis* was common, but restricted to permanent and temporary pools in bog and grassland. Several species, *Mixophyes balbus*, *Litoria citropa*, *Litoria lesueurii* and *Litoria phyllachroa* were all restricted to fast flowing creeks or adjacent habitat.

Zoogeography and Altitudinal Succession

Seven reptiles occurred only above 800 m, and ten only above 500 m. However, as some of these have been recorded (Webb 1981) or are likely to occur (Cogger 1986; Barker and Grigg 1977; Rawlinson 1969) at lower elevations, only *C. uber*, *E. cunninghami*, *L. coventryi*, *L. entrecasteauxii*, and *T. nigrolutea* can be considered to be restricted to Rawlinson's (1969) cool temperate zone. *C. uber* and *E. cunninghami* appear to be at their eastern most limit at the escarpment (Cogger 1986). Ten species of reptiles occurred in all three zones or on the tablelands and the coastal slope but not the escarpment. Four species of reptiles, *A. muricatus*, *V. varius*, *T.*

scincoides and *C. nigrescens*, were recorded only below 500 m. However, it is likely that they occur at higher elevations (Cogger 1986; Jenkins and Bartell 1980; Webb 1981).

Littlejohn (1967, 1969, 1971) did not use the same subdivisions as Rawlinson (1969, 1971). He concluded that frog fauna of southeastern Australia comprised both a southern (exclusively Bassian) and an eastern (Bassian and Torresian) component. Many species appear to reach either their northeastern or southern limits in southeastern New South Wales (the area of this study). Littlejohn also lists for eastern Victoria many of the same species found in Bondi State Forest. Seven species of frogs were recorded only above 500 m. However only *L. ewingii* and *L. raniformis* may be restricted to higher elevations (Barker and Grigg 1977; Cogger 1986; Webb 1981).

Conservation

Existing reserves* in the area include Tennyson Creek (380 ha) and Bondi Gulf (450 ha) Flora Reserves as well as the Nalbaugh (3 763 ha) and Nungatta (6 100 ha) National Parks in Bondi State Forest to the north and south of the eastern section of Bondi State Forest. Both Nalbaugh and Nungatta National Parks and, to a large extent, Tennyson Creek and Bondi Gulf Flora Reserves are marginal unproductive forests unrepresentative of the previous extensive forest cover of the tablelands and slopes now planted to *Pinus radiata* plantation. This lack of habitat representation poses problems for the conservation of forest fauna, particularly in the tablelands section (Recher *et al.* 1980, 1987). Arboreal mammals and hollow-nesting birds have been identified as particularly sensitive groups (Recher *et al.* 1980, 1987). However, the situation with reptiles and amphibians is not clear. Small (50 ha) retained coupes and buffer strips appear to retain viable populations of small lizards and frogs (Recher *et al.* 1987; Webb 1980). This can be attributed to their relatively high population densities (Webb 1980) and their ability to survive in grassland and young pine plantations. Therefore, these taxa are unlikely to require large areas of habitat to conserve viable populations. Webb (1980) provided population size estimates for several small ground dwelling lizards in Bondi State Forest, based on mark-recapture data. Actual and estimated density figures based on sampling in 400 m² plot in grazed woodland, were: *L. entrecasteauxii* (Form B) (1 825 individuals/ha and 2 625/ha respectively), *L. guichenoti* (600/ha, 1 075/ha), *P. spenceri* (275/ha, 400/ha), *E. heatwolei* (200/ha, 200/ha). In a nearby open forest/woodland site these estimates were: *L. entre-*

casteauxii (FB) (575/ha, 800/ha) and *E. heatwolei* (400/ha, 550/ha). These data, and that of Kitchener *et al.* (1980) suggest that small areas of remnant vegetation, in the order of 10 ha, may be adequate to conserve populations of most small lizard species.

Small retained patches of forest occur commonly within timber production areas. These result from implementation of various management practices and to the presence of rough terrain and unproductive forest. As populations of some species of small lizards may be suppressed by uniform regrowth (Lunney *et al.* 1991) then these small retained patches of undisturbed vegetation assume importance as sites from which recolonization can occur. Lunney *et al.* (1991) suggest that staggering of logging operations and therefore regrowth may also be useful in conserving populations of small lizards. The combination of small retained patches of forests and staggered logging operations should ensure the conservation of these small ground dwelling lizards.

Larger reptiles such as elapid snakes and the Lace Monitor *Varanus varius* may occupy large home ranges. However, given that all of the larger species in the area appear to survive in a variety of habitats, including modified habitats, conservation of habitat may not be critical. However, until further more detailed study is undertaken on these species some caution should be exercised.

Frog population numbers may be determined by more by physicochemical conditions than reserve size alone. Therefore, selective conservation of habitats, such as riparian strips, may be adequate to conserve viable populations. This is dependent upon maintaining the integrity of these strips. Many riparian strips in pine plantation in the tablelands and escarpment area of Bondi State Forest (Recher *et al.* 1987; Webb 1981) appear to support large numbers of frogs, at least in the short term. However, when these strips are degraded by intrusion of silt and reduction in vegetative cover, frog populations, particularly species common in fast-flowing creeks, may be adversely affected.

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*Expansion of the reserve system in this area is proposed however no additional reserves have yet been dedicated.

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Obituary

JOHN K. RAISON

1932–1991

John Raison was, throughout a very active research career, a plant physiologist with special interest in membrane function in relation to temperature. However, in 1973, with his student E. J. McMurchie, he published a paper contrasting the properties of mitochondrial membranes from hearts of ectotherms and endotherms. This led to a 1975 paper (again with McMurchie) "Hibernation and homeothermic status of the echidna", and from then on John made a continuing and important contribution to hibernation research. Perhaps this was not completely consistent with his position as a Chief Research Scientist (from 1982) in the Plant Physiology Unit of the CSIRO Division of Food Technology, but his spirit of scientific inquiry and curiosity would not allow him to set aside a challenging line of research. He did, of course, continue his more appropriate (within the narrowest sense of the word) research on chilling injury and phase transitions in plant membranes. Unfortunately the body could not keep up with the mind, and after a long battle with decreasing lung function, he was retired from CSIRO in August 1988.

His active mind could not slow down, and computers, which had always fascinated him and which he mastered easily, offered a continuing line of scientific activity. Even prior to his retirement, he had been of great assistance to the Royal Zoological Society's BATWATCH programme, devising an ingenious way of storing and graphing data on bat sightings. Related to this, his help was sought in sorting out the increasingly cumbersome RZS membership system. Right up to his final hospitalization, he worked on these files and updated the entire process. For John there was always more to do, and no doubt his mind would never be finished with inquiry, but on March 21 1991, the body gave up. He will be sorely missed by his friends at the RZS and by the scientific community throughout the world.

M. L. Augée
Sydney, April 7, 1991